Traumatic Brain Injury

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Overview

In US HI responsible for 33% trauma deaths.

Closed HI
80%

Missile / Penetrating HI
20%
# Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye opening</strong></td>
<td></td>
</tr>
<tr>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td>To speech</td>
<td>3</td>
</tr>
<tr>
<td>To pain</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td><strong>Best Motor Response</strong></td>
<td></td>
</tr>
<tr>
<td>Obeys</td>
<td>6</td>
</tr>
<tr>
<td>Localizes</td>
<td>5</td>
</tr>
<tr>
<td>Withdraws</td>
<td>4</td>
</tr>
<tr>
<td>Abnormal flexion</td>
<td>3</td>
</tr>
<tr>
<td>Extensor response</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td><strong>Verbal Response</strong></td>
<td></td>
</tr>
<tr>
<td>Oriented</td>
<td>5</td>
</tr>
<tr>
<td>Confused conversation</td>
<td>4</td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td>Incomprehensible sounds</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
</tr>
</tbody>
</table>
# Prognosis

<table>
<thead>
<tr>
<th>GCS</th>
<th>Injury Severity</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>13–15</td>
<td>Mild</td>
<td>0.3 %</td>
</tr>
<tr>
<td>9–12</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>≤8</td>
<td>Severe</td>
<td>25–80 %</td>
</tr>
</tbody>
</table>
Subdural Hematoma

Most common focal intracranial lesion – 24%

Mortality 50% - brain damage from:

1. ↑ ICP ⇒ ↓ cerebral blood flow / oxygenation
2. toxic effects of blood in subdural space

Tx – prompt surgical evacuation – longer delay = more severe ischemic damage
Epidural Hematoma

• Less common – 6% of severe closed HI
• Almost always associated skull fracture
• Mortality \( \approx \) preop neurologic status:
  - no coma = 0%
  - obtunded = 9%
  - deep coma = 20%
• Tx = rapid surgical evacuation
Intracerebral Hematoma

- 10% of severe closed HI

- Can be present:
  - on initial presentation
  - delayed (24-48 hours) - often associated with clinical deterioration

- Indications for surgery controversial
Diffuse Axonal Injury

= traumatic coma > 6 hours

- No mass lesion requiring surgery
- Microscopic damage throughout the brain

<table>
<thead>
<tr>
<th>Mild</th>
<th>coma 6-24 h duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>coma &gt; 24h without decerebrate posturing</td>
</tr>
<tr>
<td>Severe</td>
<td>coma &gt;24h with decerebrate posturing</td>
</tr>
<tr>
<td></td>
<td>mortality 50%</td>
</tr>
</tbody>
</table>
Effects of HI - Cardiopulmonary

1. Abnormal breathing patterns – from ↑ICP
2. Airway obstruction
3. Hypoxemia – 30-50%
4. Shock
5. Adult respiratory distress syndrome
6. Neurogenic pulmonary edema – often fatal
7. Fat embolism
8. ECG changes – uncertain mechanism
9. Diaphragmatic paralysis
Effects of HI - Endocrine

• Anterior pituitary insufficiency rare
  • e.g. GH, LH, FSH

• Posterior pituitary insufficiency:
  – Diabetes insipidus
    • usually in association with basal skull fracture
  – Syndrome of inappropriate ADH secretion
    • develops 3-15 dy after trauma – lasts 10-15 dy
## DI vs SIADH

<table>
<thead>
<tr>
<th>Pathophysiology</th>
<th>DI</th>
<th>SIADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurogenic</td>
<td>Inadequate ADH</td>
<td>Excess ADH</td>
</tr>
<tr>
<td>(Nephrogenic)</td>
<td>lack of ADH</td>
<td>insensitivity to ADH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptoms &amp; signs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental status changes</td>
<td>weakness, lethargy, seizures, coma</td>
<td>Mental status changes</td>
</tr>
<tr>
<td>Dehydration, polyuria, polydipsia,</td>
<td></td>
<td>HA, N&amp;V, seizures, coma</td>
</tr>
<tr>
<td><strong>Hypernatremia</strong></td>
<td>Low urine osmolarity</td>
<td><strong>Hyponatremia</strong> (&lt; 130 mEq/l)</td>
</tr>
<tr>
<td>High urine osmolarity</td>
<td>low urine output</td>
<td>High urine osmolarity</td>
</tr>
<tr>
<td>Hyperosmolarity (&gt; 320 mOsm)</td>
<td>Hypoosmolarity (&lt; 270 mOsm/l)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D5\textsuperscript{1/4}NS</td>
<td>NS, fluid restriction</td>
<td></td>
</tr>
<tr>
<td>Neurogenic – vasopressin</td>
<td>Demeclocycline</td>
<td></td>
</tr>
<tr>
<td>DDAVP (desmopressin)</td>
<td>(beware rapid correction)</td>
<td></td>
</tr>
</tbody>
</table>
| Chlorpropamide | \( \Rightarrow \text{central pontine myelinolysis} \)

(Urinate Na > 20 mEq/l)
Decreased BUN, Creatinine, albumin
Effects of HI - Metabolic

• Glucose intolerance

• CSF metabolic changes

• Nonketotic hyperosmolar hyperglycemic coma
  – assoc with DI, ↑ICP and uniformly fatal
Effects of HI - Hematologic

DIC from:
- release of brain thromboplastin
- fat emboli
- shock
- sepsis
Effects of HI - Skeletal

• 20% have spinal cord injury

• Maxillofacial injuries:
  – carotid artery injury
  – vertebral artery injury
  – Horner’s sy
Cerebral Perfusion Pressure

$$CPP = MAP - \text{(highest of CVP or ICP)}$$
Cerebral Autoregulation

Cerebral Blood Flow (ml/min/100g) vs. Mean Arterial Pressure (mmHg)
Intracranial Pressure

- Normal resting ICP = 0-15 mmHg
- Transient ↑ with:
  - straining
  - coughing
  - position
- Sustained ICP > 20 mmHg abnormal
Intracranial Pressure

20-40 mmHg = moderate intracranial HTN
>40 mmHg = severe, life-threatening

Intracranial HTN ⇒ global or local ischemia
(from compression of intracranial vessels)

If CPP < 40 mmHg ⇒ mortality > 90%
Anesthetic Induction

1. Airway control:
   a) Preserve oxygenation & CO$_2$ elimination
   b) Prevent aspiration

2. Maintain systemic BP to maintain CPP
   - hypotension rarely from HI alone
   - no advantage of colloid over crystalloid
   - ↓ dose of induction agent if hypovolemia suspected
Anesthetic Induction

3. Minimize ↑ in ICP – therefore:
   - controlled ventilation
   - sedation & paralysis
   - elevate head of bed 15-30° (unless hypotension)
   - mannitol for herniation / neurologic deterioration

• Monitor all pts with GCS < 8
• Only contraindication = severe coagulopathy
Anesthetic Induction

4. 10% have C-spine injury
   • obtain lateral C-spine XR before intubation (unless deep coma)
   • Manual inline axial stabilization

5. Evidence of basal skull fracture = contraindication to nasal intubation
Anesthetic Induction

6. Drugs to avoid:

i. Ketamine

ii. N₂O

iii. Sodium nitroprusside - ↑ ICP

iv. Hydralazine - ↑ ICP

v. Nitroglycerine - ↑ ICP

– Corticosteroids not useful in head injury
Anesthetic Induction

7. Lidocaine can blunt response to intubation

8. Succinylcholine is appropriate after HI
Postop Concerns

Intracranial HTN 50-70% after evacuation

1. postop hematoma (old site or new site)
2. progressive swelling of focal contusion
3. diffuse brain swelling

Therefore keep ICP < 20-25 mmHg:

– hyperventilation
– mannitol
– CSF drainage
– head up position
– barbiturate coma (*be aware hypotension*)
Postop Concerns

Systemic HTN can ⇒ ↑ICP / edema

Therefore keep SBP < 160 mmHg:

- Sedation
- β-blockers (e.g. propranolol, labetolol)
- α-agonists (e.g. clonidine, alpha-methylldopa)
Postop Concerns

Fever can:
- ↑ICP
- ↑ cerebral metabolic demand
- worsen outcome

Tx with:
- antipyretics
- cooling blankets
Postop Concerns

Prophylactic antiseizure medication not recommended
# Pediatric HI

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
<th>Age</th>
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<tbody>
<tr>
<td><strong>Eye Response</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneously</td>
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<td>To pain</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Best Motor response in upper limbs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obeys commands</td>
<td>6</td>
<td>&gt;2 years</td>
</tr>
<tr>
<td>Localizes to pain</td>
<td>5</td>
<td>6 months – 2 years</td>
</tr>
<tr>
<td>Normal flexion to pain</td>
<td>4</td>
<td>&gt;6 months</td>
</tr>
<tr>
<td>Spastic flexion to pain</td>
<td>3</td>
<td>&lt;6 months</td>
</tr>
<tr>
<td>Extension to pain</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Best verbal response</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oriented to place</td>
<td>5</td>
<td>&gt;5 years</td>
</tr>
<tr>
<td>Words</td>
<td>4</td>
<td>&gt;12 months</td>
</tr>
<tr>
<td>Vocal sounds</td>
<td>3</td>
<td>&gt;6 months</td>
</tr>
<tr>
<td>Cries</td>
<td>2</td>
<td>&lt;6 months</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Pediatric HI

In infants, systemic hypotension can result from brain injury alone.
Pediatric HI

• Epidural hematoma less common in children

• Diffuse brain swelling more common

Tx = control ICP:

– Hyperventilation

– Prevent hypoxia - maintain normal Hb and BP